Report for 2002WI4B: Removal of Arsenic in Groundwater Using a Novel Mesoporous Sorbent

There are no reported publications resulting from this project.

Report Follows:

Progress Report of WRI

Title: Removal of Arsenic in Groundwater Using Novel Mesoporous Sorbent

The highly ordered mesoporous silica media, SBA-15, was synthesized and incorporated with iron, aluminum, and zinc oxides using an incipient wetness impregnation technique. Adsorption capacities and *kinetics* of metal-impregnated SBA-15 were compared with activated alumina which is widely used for arsenic removal. Media impregnated with 10% of aluminum by weight (designated to Al_{10}SBA-15) had 1.9~2.7 times greater arsenate adsorption capacities in a wide range of initial arsenate concentrations and a 15 times greater initial sorption rate at pH 7.2 than activated alumina. According to our previous x-ray photoelectron spectroscopy (XPS) study, the oxidation phase of aluminum incorporated onto the surface of SBA-15 was assigned to Al-O, which has lower oxidation state than activated alumina (Al_2O_3). By employing the one- and two-site models, surface complexation modeling was conducted to investigate the relationship between the aluminum oxidation states in different media and adsorption behaviors such as *isotherms* and *kinetics*. Surface complexation modeling results for arsenate adsorption edges conducted with different pH showed that Al_{10}SBA-15 have a dominated monodentate complex ($SAsO_4^{2-}$) while activated alumina have bidentate complexes ($XHAsO_4$ and $XAsO_4^-$) at pH 7.2, respectively. In *kinetic* studies at pH 7.2 ± 0.02, Al_{10}SBA-15 has only a fast-rate step of initial adsorption while activated alumina has two different fast- and slow-rate steps of arsenic adsorption. Therefore, it can be inferred from Grossl *et al.* that the monodentate arsenate complex predominant in Al_{10}SBA-15 is leading to faster adsorption rates than bidentate arsenate complexes favored at activated alumina. Therefore, the overall results suggest that the arsenate adsorption behavior and arsenate surface complexation might be well explained by aluminum oxidation states and surface structural properties of media.

Using an incipient wetness impregnation, $La(NO_3)_3 \cdot xH_2O$ (where $x = 3 \sim 5$) was impregnated for calcined SBA-15. Through the FTIR analysis, it was found that there was no structural collapse of pore structures occurred by the attacks of lanthanum precursors for Si-O bonds. This phenomenon is different with aluminum impregnation, in which a structural collapse occurred at 30% of aluminum impregnation. As a result of arsenate *kinetic* tests, La_{20}SBA-15 had an arsenate adsorption capacity of 0.95 mmol/g or 70.8 mg/g, which is about 10-fold higher adsorption capacity than that of activated alumina. In addition, *Kinetic* trends of lanthanum impregnated SBA-15 and lanthanum oxide were very similar and have higher determination coefficients (R^2) of simple Elovich model than those of parabolic diffusion, which governed kinetics of aluminum impregnated SBA-15. Results of *isotherms* using bottled water exhibited that LaSBA-15 had a very strong selectivity for arsenate because its adsorption capacities were not deteriorated by several other anionic species, such as sulfate, nitrate, and chloride. This result agreed well with Wasay *et al*., in which arsenate adsorptions of lanthanum impregnated silica gel were not reduced with other anions such as Cl^-, Br^-, I^-, NO_3^-, and SO_4^{2-}.

Through several characterization studies and adsorption *kinetic* or *isotherm* tests, lanthanum was found to be a good candidate of functioning chemicals to have highly active sites for arsenate adsorption. Considering higher adsorption capacity and fast sorption rate of arsenate removal, lanthanum incorporated SBA-15 may be one of prospective adsorption media for arsenic removal. A series of column tests is being performed to determine adsorption capability, minimum effluent arsenic concentration, time for regeneration, and loading rate.

References

Presentation

Jang, M., E.W. Shin, and J.K. Park. Removal of Arsenic Using Metal-Impregnated Mesoporus Media. 75th Annual Water Environment Federation Conference, Chicago, Sept. 29-Oct. 2, 2002.

Paper

Jang, M., E.W. Shin, J.K. Park, and S.I. Choi. Mechanisms of Arsenate Adsorption by Highly-Ordered Nano-Structured Silicate Media Impregnated with Metal Oxides. Submitted to *Environmental Science and Technology*, 2003.

Patent

Park J.K. and M. Jang. "Removal of Arsenic and Other Anions Using Novel Adsorbents," Patent (US Patent) Proceeding.